

A MULTI-LEVEL NUMERICAL MODEL TO ASSESS THE HEPATIC CIRCULATION IN CASE OF HUMAN CIRRHOSIS

Aim: Liver cirrhosis is a chronic liver disease affecting both liver architecture and perfusion by the formation of fibrosis, regenerative nodules, shunt vessels etc. This process impairs the hepatic circulation and may elevate the intrahepatic vascular resistance (IVR). To gain more insight in the hemodynamic consequences of cirrhosis, multiscale models were developed.

Methods: Vascular corrosion casting and multi-level micro-CT imaging (up to a 1.7 μm resolution) were applied to an excised human cirrhotic liver. Image processing enabled 3D reconstructions of the cirrhotic microcirculation which formed the basis for computational fluid dynamics (CFD) simulations. In addition, a simplified 3D CFD model of the cirrhotic macrocirculation was constructed to analyse the effect of the presence of regenerative nodules (lacking sufficient perfusion) on IVR.

Results: The macrocirculation model indicates that regenerative nodules may severely increase the IVR, with a low ($\times 1.5$), moderate ($\times 2.9$) and steep ($\times 17$) increase corresponding to a nodular volume percentage of 30%, 60% and 83%. In contrast, the micromodels suggest that local compensation mechanisms are present to counteract the macroscopic IVR effect. For example, shunt vessels and dilated sinusoids decreased the IVR by a factor 30 and 5.5 respectively, compared to normal liver tissue.

Conclusions: Numerical modelling allows quantifying the perfusion characteristics of the cirrhotic macro- and microcirculation, i.e. the effect of regenerative nodules and compensation mechanisms.